Wednesday, September 09, 2015
3:30 PM

Physics 11

Welcome

Course Outline/introduction

Getting to know you

What is Physics?

What is Physics?

Monday, September 14, 2015
8:42 AM

Measurement

Physics is an experimental discipline therefore all hypotheses are tested through observation. Observations are quantified by measurement. Measurement is just comparing an observation to a standardized value.

Metric system, SI

base units:	derived units:
length: metre, m	cm, km,
time: seconds, s	hours, years
Temperature: Kelvin,K	Celsius, C
Mass: kilogrom, kg	g,
Volume:	litres, l, ml=cm^3 1000 000 cm^3 = 1 m^3
Energy:	Joules, J
Force:	Newton, N

For large or small values we either give the value in scientific notation or use prefixes.

923845 m = 9.23845×10^5 m = 923.845 km = 0.923845 Mm

Prefixes	Power of ten		
deca, de	10	deci, d	10^{-1}
hecta, h	10^{2}	centi, c	10^{-2}
kilo, k	10^{3}	milli, m	10^{-3}
Mega, M	10^{6}	micro, μ	10^{-6}
Giga, G	10^{9}	nano, n	10^{-9}
Tera, T	10^{12}	pico, p	10^{-12}
peta, P	10^{15}	femto, f	10^{-15}

Converting units using a unit fraction:

how many seconds are in a year?

to solve a more complicated unit conversion, you can multiply the value by a unit fraction, a fraction with the top and bottom values being equivalent.

1 year (365.25 days/year)(24 hrs/day)(60min/hr)(60s/min)

=365.25x24x60x60= 31557600 s in a year

speed limit is 50 km/hr conver that to m/s.

Measurement
SI system, prefixes, unit fractions, Lab outside

Physics:
What is physics?
Study of matter and energy/forces.
Fundamental science - underlying Laws of Nature.
Experimental discipline so hypotheses are tested against observation. We quantify observation with measurement - comparing observations to a standardized unit system.

Metric system, SI system

Base units:	derived units:
length: metre, m	km, cm, light year,
time: second, s	minute, min - hr, year
mass: kilogram, kg	g, ton,
area:	cm^2
volume:	litre, ml=cm^3 1000000cm^3=1m^3
electric current: Ampère, A	
electric charge,	Coulomb, or elementary charge
energy:	Joule, J

If you are dealing with really small or really big values, you either put it in scientific notation or use a prefix.

eg. the radius of the earth is 6 380 000 m
6.38×10^6m
or 6 380 km
6.38 Mm

Prefixes	Power of ten		
deca, de	10	deci, d	10^{-1}
hecta, h	10^2	centi, c	10^{-2}
kilo, k	10^3	milli, m	10^{-3}
Mega, M	10^6	micro, μ	10^{-6}
Giga, G	10^9	nano, n	10^{-9}
Tera, T	10^{12}	pico, p	10^{-12}
peta, P	10^{15}	femto, f	10^{-15}

How many seconds in a year?

How fast is 50 km/h in m/s?

Unit conversions using unit fractions:

to convert a value from one unit to another, to make sure you get it the right way, multiply by a unit fraction so that the old unit cancels out.

a unit fraction has the same value but different units in the numerator and denominator.

eg.

1 year(365.25d/y)(24h/d)(60min/h)(60s/min)

unit fraction

365.25d = 1y

= 365.25x24x60x60=31,557,600 s in one year

3.16×10^7s

50 km/h (1000m/km)(h/3600s)

50x1000/3600=13.8889

14m/s

Converting units Worksheets
Accuracy, Precision - Significant Digits - Lab sheet

nm = 10^{-9}m

eg. You walk 7.2 m in 3.1s. What is your speed in
a) m/s b) km/h c) light years/s d) nm/s

a) 7.2m/3.1s = 7.2/3.1=2.3226 =2.3m/s
b) 2.3226 m/s (km/1000m) (3600s/hr)
2.3226/1000x3600=8.3614 =8.4km/h
c) 1 light year = 3.0×10^{8}m/s x 1year(365.25d/y) (24h/d)(3600s/h)
300000000x365.25x24x3600=9.47E15
9.47×10^{15}m = 1 light year
2.3226 m/s (1 light year/9.47×10^{15}m)
= 2.3226/9.47×10^{15}=2.452×10^{-16} =
2.5×10^{-16}lightyears/s

d) 2.3226 m/s (1nm/10^{-9}m)
=2.3×10^{9}nm/s

Accuracy and Precision

All measurements are limited in accuracy and precision by the equipment, your use of the equipment or

Heisenberg's uncertainty principle (you can't know position and momentum infinitely precisely)

Accuracy: Your measurement is dead on the real value. (like hitting a bulls eye with an arrow).
quantify the accuracy of a lab by calculating the
%error = |experimental - theoretical|/theoreticalx100%

eg. you measure the density of a block of aluminum at $2.2g/cm^3$ but the theoretical value (in the book) is $2.70g/cm^3$. What is your % error?

%error = |experimental - theoretical|/theoreticalx100%
$= |2.2g/cm^3-2.70g/cm^3|/2.70g/cm^3x100\%=$
2.2-2.7=-0.5
$0.5/2.7=0.1852 = 19\%$ error $= 2 \times 10^1\%$ error

Precision - If you repeat a measurement, how close are the values to each other? Closer= more precise.
- like shoot arrows, and they are all bunched together it is precise.

but not precise

accurate

Quantify precision -

1. repeat a measurement and see the range of uncertainty. eg. 2.40cm, 2.63cm, 2.50cm
   range of uncertainty is +/-0.1cm so you should give the value as
   2.5 +/-0.1cm
   implied in 2.5cm, the number of digits implies the uncertainty
2. smallest division on the device.
   eg. ruler measures to the mm, +/- 0.5mm
   stopwatch measures to the hundredth, +/-0.01s
3. estimate it from your assessment of factors of the apparatus.
   eg. stopwatch, students reaction time is about 0.1s, so uncertainty is +/- 0.1s

Significant figure rules:
All measurements have a limited number of digits implying the precision.

is 2.0s different than 2 s or 2.00s?
they have different uncertainties implied

rules for sig figs, all non-zero digits are significant.

3.32 has 3 sig figs
443.4 has 4 sig figs

zeros in the middle or after a sig fig and after a decimal are significant
303 has 3
2.00 has 3 sig figs

but zeros used for place value are not significant

0.0000020 has 2 sfs
count

3.0×10^7 has 2 sf

300 has assume 1
unclear
?

3.0×10^2
3×10^2

Rules:

Multiplying and Dividing Measured Values.

Round your answer to the lowest number of significant digits of the starting values.

eg. 1.0 x 2.7050 = 2.705 = 2.7

2 sfs 5 sfs

Adding/subtracting rule:

Round your answer to least precise decimal place of the starting values.

eg. 12.502 - 9.6

12.502 − 12.1 = 0.402 → 0.4

12.502
9.6
2.902 = 2.9

Converting units Work
Accuracy, Precision - Significant Digits

Traffic Lab
say that you paced off 7.2m and someone ran it in 2.1s. Determine the speed in
a) m/s b)km/h c)light years/s d)nm/s

a) v=d/t = 7.2m /2.1s 7.2/2.1=3.4286 = 3.4 m/s
b) 3.4286 m/s (km/1000m)(3600s/h)
3.4286/1000x3600=12.343 = 12km/h
c) v=3.0x10^8m/s 3E8 or 3EXP 8
d=vt = 3x10^8m/s(1y)(365.25d/y)(24h/d)(3600s/h)
300000000x365.25x24x3600=9.47E15
9.47 x 10^{15}m = 1 light year
3.4286 m/s (1lightyear/9.47x10^{15}m)
3.4286/(9.47x10^{15}) = 3.6 x 10^{-16} light year/s

d) 3.4286 m/s (nm/10^{-9}m)
3.4x10^9 nm/s

Accuracy and Precision

Accuracy - How close to the actual or theoretical value is the measurement?

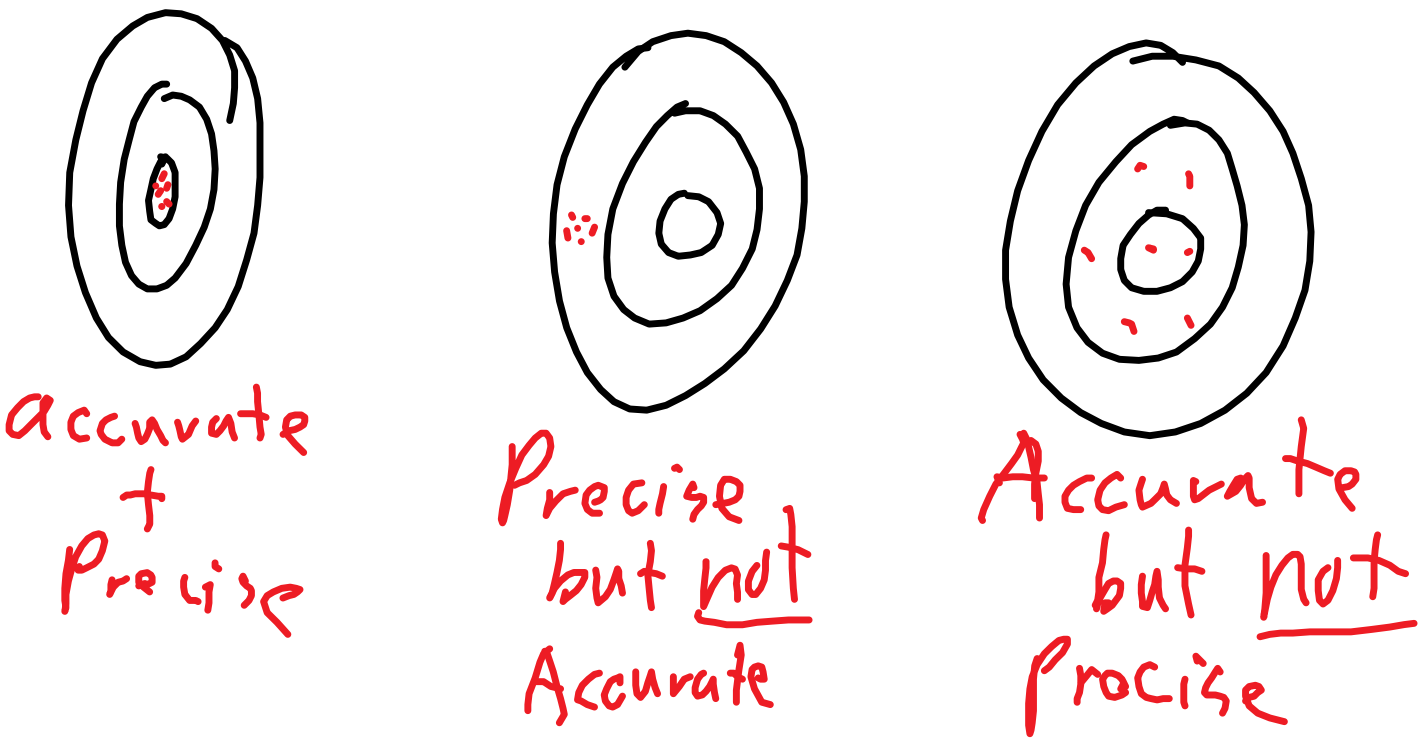
quantify accuracy by the percent error, %error
%error = |experimental-theoretical|/theoreticalx100%

eg. you measure the density of an aluminum block to be 2.2 g/cm^3 while the book value is 2.70g/cm^3. What

is your % error?

%error = |experimental-theoretical|/theoreticalx100%
%error= |2.2g/cm^3-2.70 g/cm^3|/2.70g/cm^3 x 100%
2.2-2.7=-0.5
0.5/2.7=0.1852   x100% = 19% or 2x10^1%

Precision - if you repeat a measurement, what is the range of values? small range, small uncertainty in the measurement so it is precise.



methods to determine precision:

1. repeat the measurement. The range of values is the uncertainty range and determines the number of digits that are significant.
   eg. you measure the length of a pen at 10.50cm 12.13 cm and 11.32 cm, the range is

12.13-10.50=1.63
uncertainty is +/- 1.63/2=0.815 +/-0.8
11 cm +/- 1cm
or just 11cm because that implies +/-1
if you give the value at 10.50cm you imply +/- 0.01

2. the smallest division on the instrument can be an estimate of the precision.
   eg. rulers measure to the mm, so +/- 1 mm or 0.5mm
3. the uncertainty can be estimated from other factors
   eg. a stopwatch is limited by the reaction time of the user, about 0.1s

Significant Digits Rules:
All measurements are limited in precision by the instrument, the user and Heisenberg's uncertainty principle(atomic level).

All measurements have limited digits that are significant, Sig Figs or Significant digits or figures or SFs.

look at 2s or 2.0s or 2.00s.
They are all the same value but to different precisions.
2s has 1 digit and implies +/- 1s
2.00 has 3 digits implies +/- 0.01s

Rules:
all non zero digits are significant
eg. 343 has 3 sfs
zeros after a significant digit and after the decimal are significant
2.00 has 3 sig figs
zeros between sig figs are significant
eg 303.0 has 4 sig figs
zeros for place values are not significant or are unclear
eg. 0.0000002 has only 1 sig fig, the 2
3000 has ? sig figs, it is unclear. (in Chem they will say 3000 has 1 sig fig)
3×10^3 has 1 sig fig
3.0×10^3 has 2 sig figs

Rules for
Multiplying and dividing:
Round your answer to the least number of sig figs of the numbers you start with.
eg. $1.0 \times 34.89 = 3 \times 10^1$

Adding and subtracting
Round the answer to the least precise decimal place.
eg. 1.0 + 34.89 = 35.89

1.0 ← tenth
hundredth
tenth

$$\begin{array}{r} 1.0 \\ +\ 34.89 \\ \hline 35.89 \end{array} \rightarrow \boxed{35.9}$$

← hundredth

tenth

Lab Report Guide Sheet

Title, name and partners name labeled
problem or aim or purpose
Hypothesis - statement of how things work that you test.
Procedure or process - Don't copy out procedure, just say "refer to lab manual p__"
but write out any changes

Observations:
table with a title and units
be careful of significant digits - related to uncertainty

Analysis- graph data and find an equation
calculate the %error if you have a testable value

conclusion - State whether the data supports your hypothesis, and how close is it. Never say "prove".

Sources of Uncertainty - factors that influence the validity of the data.

- equipment - ruler has an uncertainty of +/- 1 mm.
- look at the data for support - is the data shifted?

Lab Report Guidelines:

What do you include in a lab report?

Title name and label partner's name
purpose or aim or problem - variables you test.
Hypothesis or theory - statement of how things work that you test.
Procedure - don't copy out the procedure, just write "refer to lab manual p___" but write out your contribution.
Observations -
table with a title and units
be careful of sig figs
quantitative

Analysis-
graph with a derived equation
show sample calculations
calculate %error

Conclusion - Does the data support the

hypothesis? How closely?(%errror)
never say "prove"

Sources of Uncertainty - List factors that limit the validity of the data.
equipment - specify the range of uncertainty
eg. a ruler will measure to the mm
look at the data and see patterns

Graphing Data **<u>to Get an Equation</u>**

http://physics-pages.wikispaces.com/Graphing+tips

What to include in a graph?

Title - describes the experiment, not just v vs t

axes - labels, units and a consistent scale

choose the scale so the data takes up over half the page - gives better precision

data points and a best-fit line (shows the trend of the data - does not connect the dots or necessarily go through the origin. Can be a curve if the data is non-linear.)

If the data is linear

use a ruler to draw the best-fit line, then choose two points <u>on the line</u>, not necessarily data points, far apart that you make a triangle for the rise and run.

slope, m=rise/run - make sure you include units and round to usually 2 or 3 sig figs.

y-intercept, b = point on the y axis where the line hits and x=0. If you offset x data, then input a point on the line into y=mx+b and solve for b.

Last step:

replace every term in y=mx+b to give the equation.

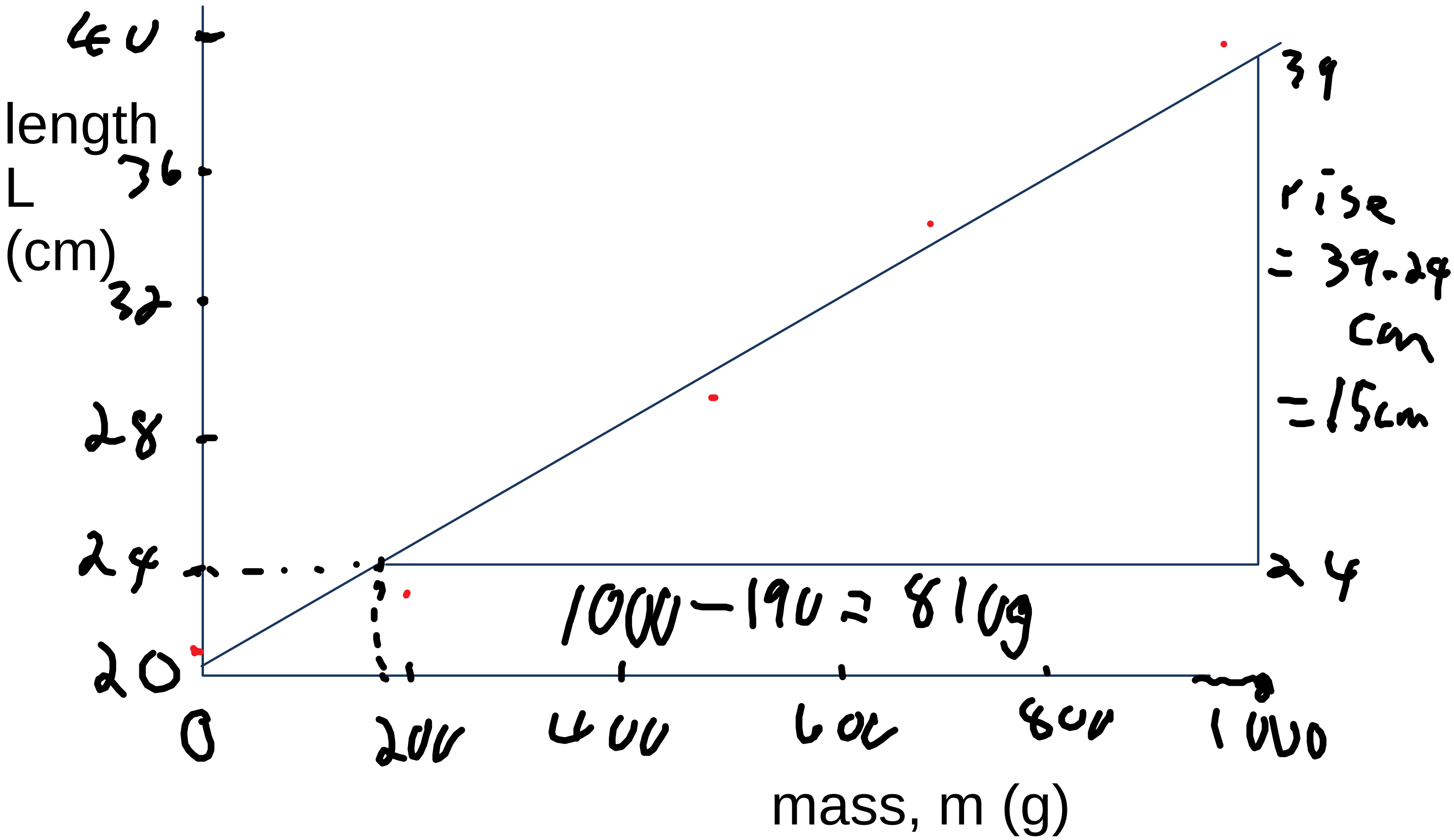
y is the y axis variable, x is the x axis variable, m is slope with units and 2 or 3 sig figs, b is y intercept with units and 2 or 3 sig figs.

eg.
Lets do an experiment, hang masses on a spring and observe the length of the spring.

independent variable goes on the x axis, mass is the independent variable because we control it.

length, cm	mass, g
21.0	0
22.8	200
29.0	500
32.7	700
39.0	1000

title: length of a spring with masses



Show on graph

Slope $m = \frac{rise}{run} = \frac{15cm}{810g}$

m =
15/810=0.0185
m = 0.018 cm/g

y intercept = 20.5 cm = 21 cm
y=mx+b
replace y with the variable on the y axis
L=0.018cm/g m + 21cm

L=0.018cm/g m + 21cm

%error= |exp-theo|/theo x 100%

eg. in the lab your density of aluminum is 2.90g/cm^3 but the theoretical value is 2.70g/cm^3, determine the % error.

%error= |exp-theo|/theo x 100%

= |2.90g/cm^3 - 2.70g/cm^3|/2.70g/cm^3

0.2/2.7=0.0741 = 7.4 %

Graphing Data **to Find an Equation**

title - describes the experiment - not v vs t, try the velocity of a cart rolling down a hill
axes with labels, units and a consistent scale - should be set so the data takes up more than half the page.
plot points - size can show uncertainty
draw a best-fit line - should show the trend of the data, but don't connect the dots, it doesn't have to

touch any of the points or the origin necessarily.
on the graph, draw a triangle from two points on the line far apart.
slope of the line, m= rise/run of the triangle
y-intercept, b= where the lines hits the y-axis at x=0 (if you offset x, then input a point on the line into y=mx+b and solve for b)
values need units and proper sig figs, 2 or 3 depending on how good the data looks.
-Do not leave the slope as a fraction.
sub values and variables into y=mx+b for every term. F=2.0N/m L + 0.12N

eg. Put various masses on a spring and measure the length.

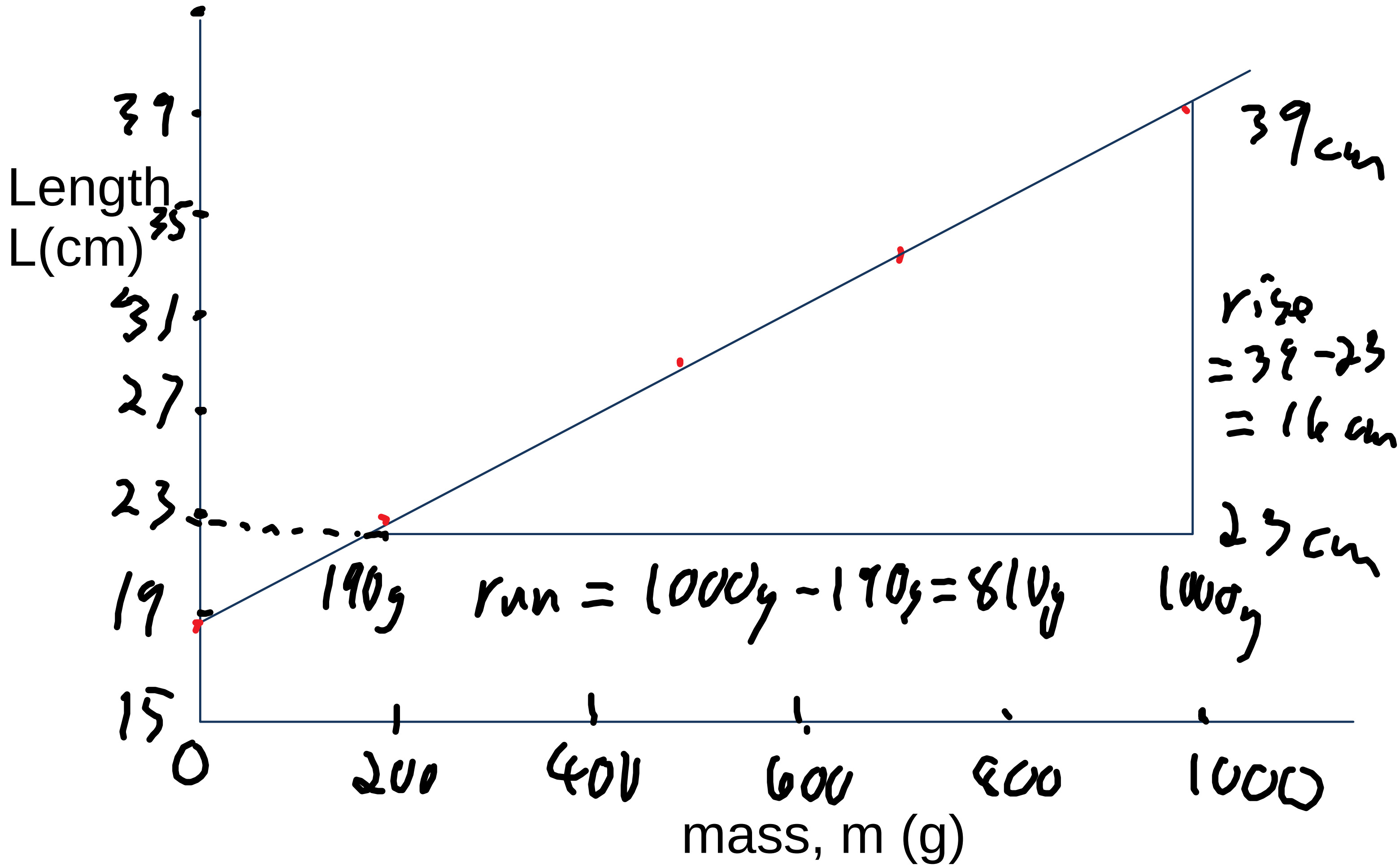
independent variable goes on the x-axis - the one you control - in this case, it is mass

mass(g)	Length(cm)
0	18.8
200	81-58=23.0
500	80.5-52=28.5
700	78.5-46=32.5
1000	78.5-39.7=38.8

graph the data and determine the equation

relating Length to mass.

title: length of a spring with masses on it



$$\text{Slope, } m = \frac{\text{rise}}{\text{run}} = \frac{16\,\text{cm}}{810\,\text{g}}$$

16/810=0.0198 $= \boxed{0.020\ \frac{\text{cm}}{\text{g}}}$ slope

y-int = 19cm

$y = mx + b$

* $L = 0.020 \frac{cm}{g} m + 11 cm$